1.1 Background

This *Progress Report* summarizes the activities of the Experimental Facilities Division (XFD) in support of the users of the Advanced Photon Source (APS), primarily focusing on the past year of operations. The personnel of XFD are proud of their progress and accomplishments and hope that the reader will share their dedication and enthusiasm in supporting the APS users.

Operation of the APS is prominent among Argonne National Laboratory's scientific endeavors. In February 1996, the Office of Basic Energy Sciences of the U.S. Department of Energy (DOE) confirmed the completion of the construction of the APS Project. The dedication of the Project followed on May 1, 1996. In September 1996, the APS began operations as a national user facility serving the U.S. community of x-ray researchers from private industry, academic institutions, and other research organizations. The start of operations was about three months ahead of the baseline date established in 1988.

The responsibility for the construction of the technical components of the APS Project was divided between the Accelerator Systems Division (ASD) and XFD. Throughout the construction period, the DOE conducted reviews, using technical consultants, of the progress of the work. When the construction phase of the Project was completed, ASD and XFD took operational responsibilities. The progress in the operational activities of the APS is now reviewed by appropriate committees appointed by The University of Chicago, which operates Argonne National Laboratory (ANL) for the DOE.

Thirty-five of the forty storage-ring sectors include both insertion-device radiation sources and bending-magnet sources. Of these 35 sectors, one sector is dedicated to ASD for particle beam diagnostics using the radiation from an undulator source and a bending-magnet source. The remaining 34 sectors will be used for research and development (R&D) work by the APS users.

The APS commissioning goal of extracting undulator radiation was met by XFD on August 18, 1995. This permitted the XFD to measure the particle beam emittance and the x-y coupling using undulator x-rays. Successful commissioning of the beamline radiation sources and front ends demonstrated the capability of this equipment to operate at a level commensurate with the technical performance goals. In addition, successful "acceptance testing" and beamline safety reviews demonstrated that the initial complement of beamlines have been developed and can be operated safely while meeting technical specifications.

In the first phase of this project, 20 of these 34 sectors are being instrumented behind the storage-ring shield wall to deliver undulator or wiggler radiation, as well as bending-magnet radiation, to the APS users. During the past year, XFD personnel have installed and commissioned insertion devices and beamline front ends consistent with the APS user requirements. In addition, the Personnel Safety Systems on all user experiment stations have been designed, installed, validated, commissioned, and operated by XFD personnel to meet users' objectives. Many of the "standard and modular" beamline components required by the user community have been designed, constructed, and tested for their performance by XFD. The design drawings of all these components are available to the user community in electronic format on the "Design Exchange" established by XFD.

With the construction project completed, during the past year XFD has enhanced its mission to prepare fully for facility operation (which began in September of 1996) and to increase its support for APS user beamline operations. Currently, 18 of the 20 undulators and wigglers required by the APS users have been installed on the storage ring, 35 of the 40 beamline front ends have been installed, and 22 (16 insertion-device and 6 bending-magnet) user beamlines in 16 of the 20 sectors, including 35 experiment stations, have started commissioning activities. These beamlines are routinely taking radiation to both commission instruments, such as monochromators, mirrors, slits, focusing optics, diffractometers, goniometers, detectors, and beamline control electronics, and to perform early research. The XFD has worked hard to provide x-rays very early in the facility operations phase for APS users to do innovative experiments.

1.2 Mission of the APS Experimental Facilities Division

The mission of the XFD is consistent with the vision of the APS to function as a reliable and preeminent source of synchrotron radiation for APS users.

XFD believes that we can best serve the APS users by investing in three important goals: reliable and successful operation, high-quality user technical and administrative support, and innovative R&D in support of user operations. These goals enable us to go beyond the traditional role of DOE user facilities to create an intelligent partnership with our users.

We commit ourselves to an organization that shares the following principles:

- understanding our users' operational goals and striving to exceed their needs
- providing seamless support to our users in all areas
- creating a rewarding, enriching, and collaborative R&D environment for our staff and the users to facilitate long-term success of the APS as the premier user facility in the world
- expanding our worldwide leadership role in the synchrotron radiation community
- assuring the safety of APS users, visitors, and APS/XFD personnel, and the protection of the environment
- approaching our daily work with enthusiasm, dedication to users and a sense of humor

1.3 APS User Sector Layout

In Figure 1.1, the layout of the APS experiment hall floor and the allocation of sectors to various Collaborative Access Teams (CATs) is shown. Each sector consists of two beamlines, one based on an insertion-device source and the other based on a bending-magnet source. The insertion devices in 18 sectors are undulators, one sector has a conventional wiggler, and the last has an elliptical multipole wiggler for the production

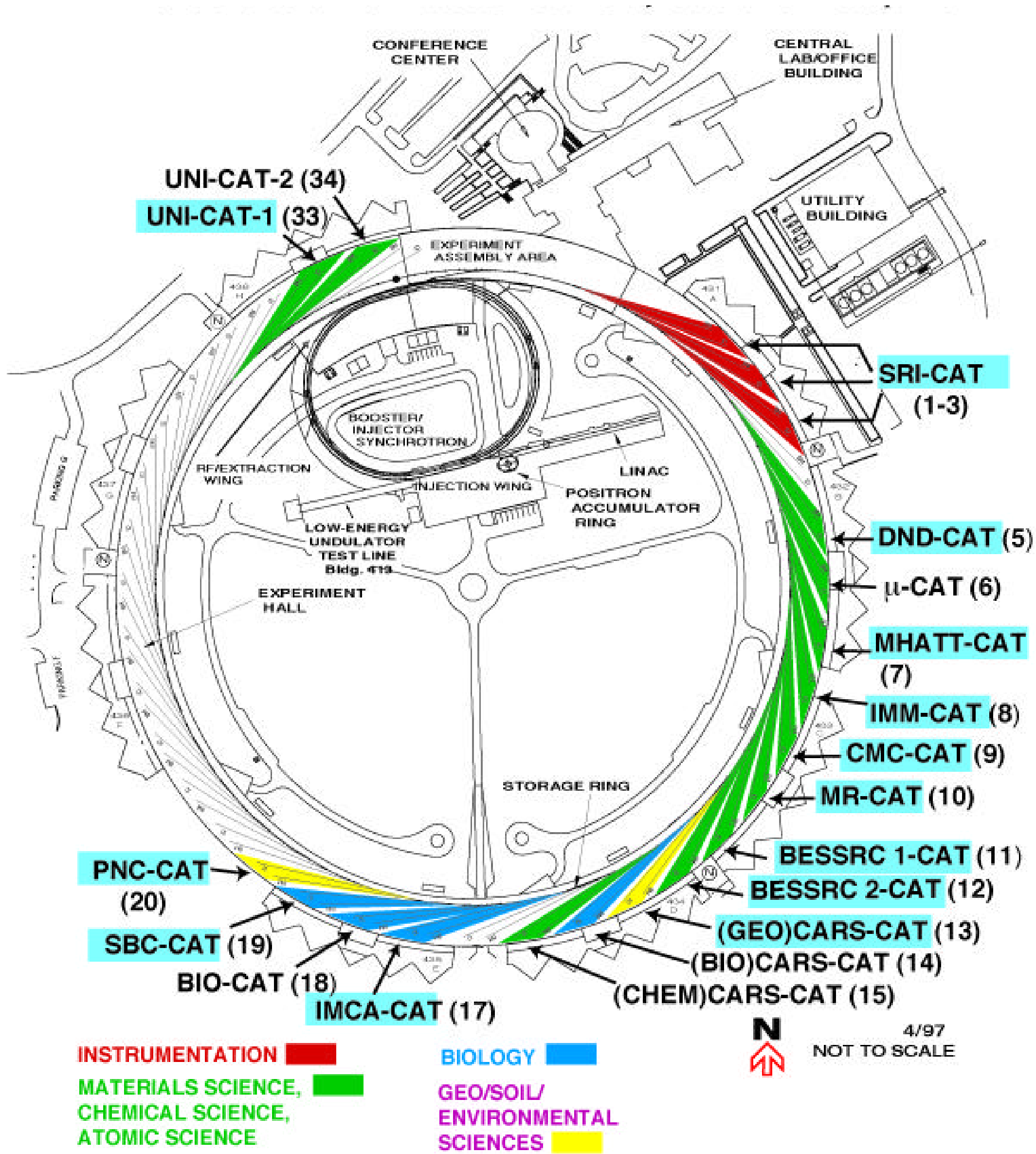

Fig. 1.1 APS Collaborative Access Teams by sector and discipline

of circularly polarized x-rays with a capability to switch the polarization helicity. Some of the CATs have taken responsibility for more than one sector. The progress of the CAT beamline construction and scientific work is evaluated at regular intervals by the APS Program Evaluation Board (PEB). The lead institutions developing the beamlines in each of the sectors is presented in Table 1.1, which also indicates the diverse scientific disciplines and technological applications being addressed by the CATs. In Figure 1.1, a broad classification of scientific interests has been shown. They are (a) condensed matter physics, chemical science, and material science, (b) health science, (c) environmental science, geoscience, soil science, and agricultural science, and (d) synchrotron

Table 1.1 Lead Institutions and Research Areas of the APS Collaborative Access Teams

Collaborative Access Team	Lead Institution	Scientific & *Technological Applications*
Basic Energy Sciences Synchrotron Radiation Center (BESSRC, Sectors 11 &12)	Argonne	Materials science; chemistry; atomic physics; geosciences. *Environmental remediation.*
Biophysics (Bio, Sector 18)	Illinois Institute of Technology	Biophysics, improved understanding of the mechanism of action of enzymes. *Industrial enzymes.*
Center for Real-Time X-Ray Studies (MHATT, Sector 7)	Howard University	Physics; materials science; chemistry. *Liquid crystals; solid-state lasers.*
Complex Materials (CMC, Sector 9)	Exxon Research and Engineering	Chemistry of complex materials. *Polymers, liquid crystals, and membranes.*
Consortium for Advanced Radiation Sources (CARS, Sectors 13, 14, &15)	The University of Chicago	Structural biology; geoscience; chemical, material, and soil/environmental sciences; improved understanding of earth and of biological processes at the molecular level. *Environmental remediation; materials and catalysts; plant fertilizers.*
E.I. DuPont de Nemours and Co.-Northwestern University-Dow Chemical Co. (DND, Sector 5)	Northwestern University	Materials science; polymer chemistry. *Technologies for microfabrication and electrodeposition; corrosion prevention: polymer fibers.*
IBM-MIT-McGill (IMM, Sector 8)	Massachusetts Institute of Technology	Materials science and physics. *Products for high technology sector.*
Industrial Macromolecular Crystallography Association (IMCA, Sector 17)	Procter and Gamble	Structural biology. *Designer drugs.*
Materials Research (MR, Sector 10)	University of Notre Dame	Materials science. *Polymers (e.g., for textiles); environmental remediation; complex chemicals.*
Midwest Universities (μ, Sector 6)	Iowa State University	Materials science. *Synthetic membranes for biological processes.*
Pacific Northwest Consortium (PNC, Sector 20)	University of Washington	Environmental and materials science. *Environmental cleanup; moldable ceramics.*
Structural Biology Center (SBC, Sector 19)	Argonne	Structural biology. *Enzymes and new drugs.*
Synchrotron Radiation Instrumentation (SRI, Sectors 1, 2, & 3)	Argonne	Synchrotron radiation instrumentation and x-ray physics. *Insertion devices and optical elements for the APS users and other synchrotron x-ray facilities.*
University-National Laboratory-Industry (UNI, Sectors 33 & 34)	University of Illinois	Materials science; structural biology. *Molecular sieves for catalysts.*

radiation instrumentation. It is in this last area that XFD has a major commitment. Through the Synchrotron Radiation Instrumentation (SRI)-CAT, we support the needs of all the CATs.

1.4 XFD Organization

The XFD was recently reorganized to meet the mission of the Division. The three functional areas of XFD are:

A. User Operations

B. User Administrative and Technical Support

C. R&D in Support of User Operations

The major objectives of the functional areas are given in Fig. 1.2 and are described in more detail in other parts of this document.

The XFD organization structure, shown in Fig. 1.3, defines various groups by specialization. This structure guarantees excellent communication and interaction across the boundaries of the groups to meet both the group and XFD objectives. The groups consist of a Group Leader and Principal Investigators with well-defined technical and supervisory responsibilities.

1.5 APS User Operations

User Operations is supported by the Beamline Operations Group, the Safety Interlocks and Instrumentation Group, and the Floor Coordinators. Their main objective is to assure the highest level of reliability of operations of the radiation sources, beamline components, and Personnel Safety Systems to support the highest level of productivity from the APS users.

These groups are responsible for the installation, commissioning, maintenance, improvement, and operations of insertion devices and beamline front ends. In addition, the groups also perform installation, commissioning, maintenance, improvement, and operations of the personnel safety and interlock systems.

These groups also gather data to perform operations reliability studies and analysis. The staff performs analysis to evaluate failure trends and assess reliability. In addition, the Floor Coordinators support beamline commissioning and oversight of operational safety.

1.6 APS User Administrative and Technical Support

This activity is supported by many groups: User Administration and Support, User Technical Interface, X-ray Optics Metrology and Fabrication, Beamline Controls and Data Acquisition, and staff involved in the operations of the Design Exchange. These groups provide seamless support to the APS users in all areas. They specifically provide

- Technical support on the experiment hall floor

- Technical support on instrumentation

- Administrative support including user safety and training

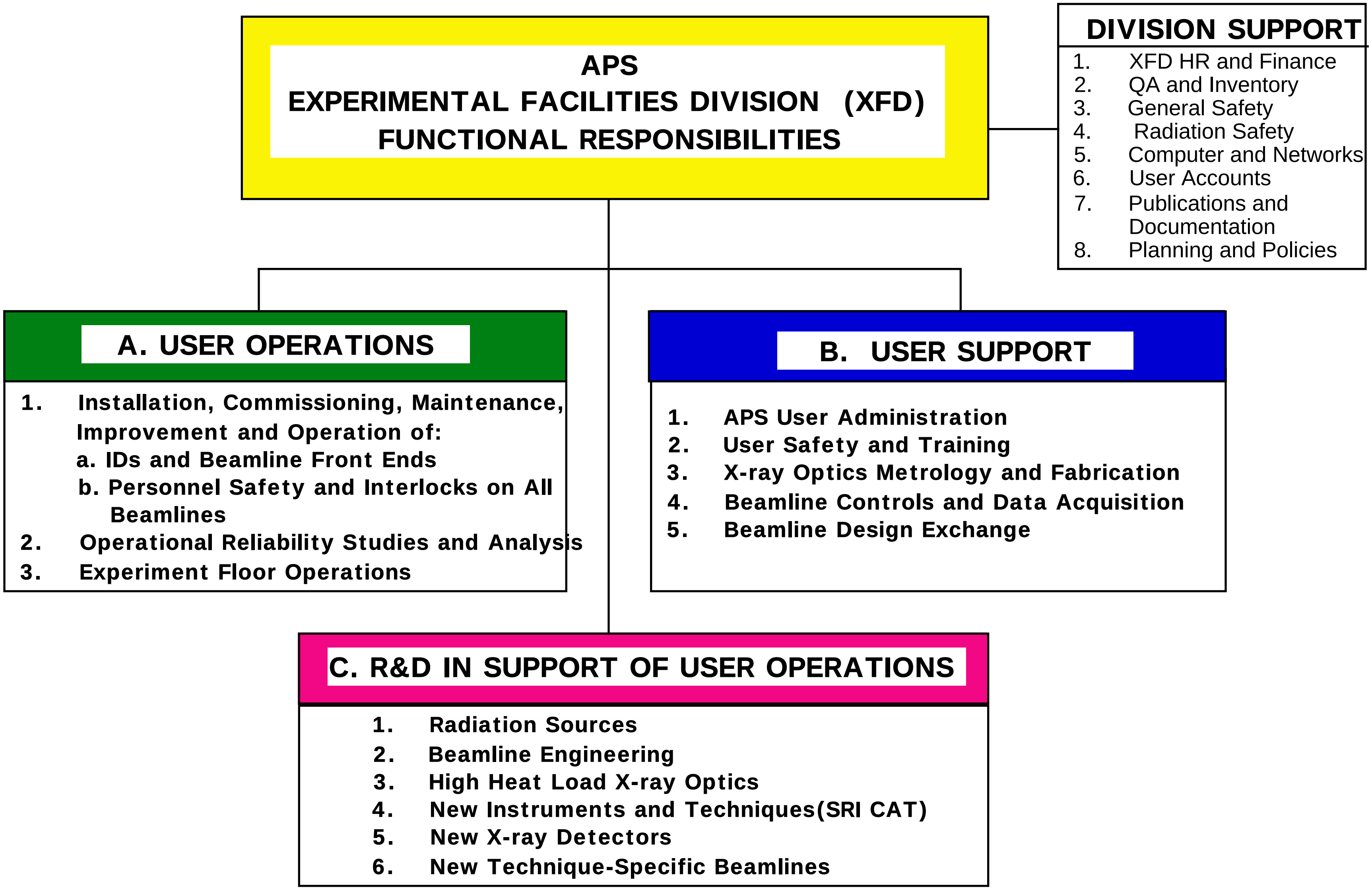

Fig. 1.2 Functional organization of the Experimental Facilities Division

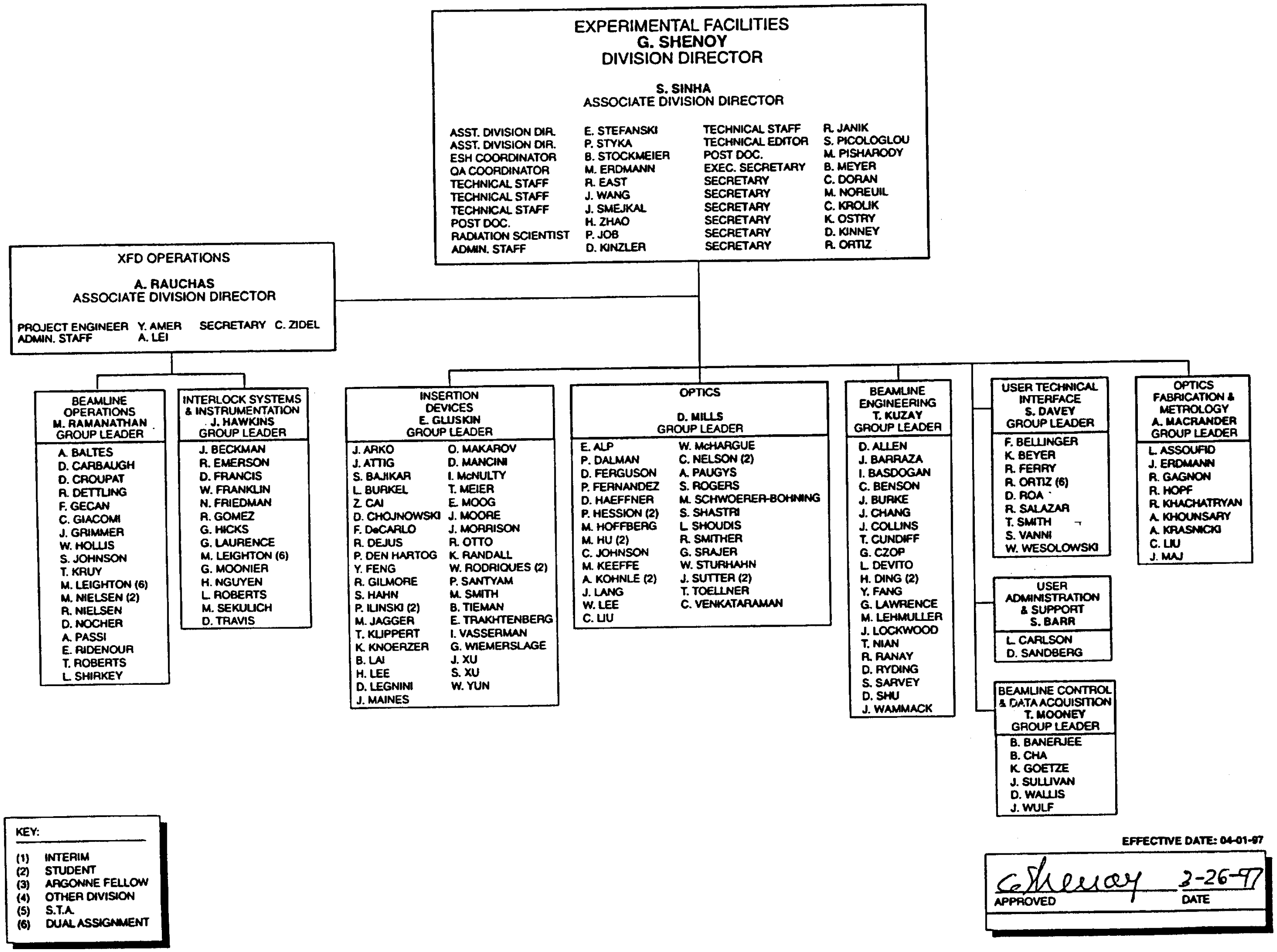

Fig. 1.3 Experimental Facilities Division organization chart

- Development of user policies and procedures

- Development and maintenance of electronic databases to manage administrative data on APS users, and to manage all APS beamline designs required by the APS users and accessed through the World Wide Web (or Web) on the Internet.

1.7 R&D in Support of User Operations

R&D in support of user operations is primarily supported by the Insertion Device Group, Beamline Engineering Group, and X-ray Optics Group. These groups support the Operations Groups by carrying out any major maintenance, repairs and upgrades required to successfully operate the components behind the shield wall. These groups also perform R&D to address future APS operational parameters, such as the "top-off" mode, 300 mA operation, and unique radiation sources. They also provide the highest quality leadership in synchrotron instrumentation and technique development in order to support and enhance the APS users' scientific goals. Some of these activities with both short- and long-term benefits to the user community are performed through SRI-CAT.

The experience of the personnel in these groups is extensive. Their work at the APS has produced numerous publications and patents. (See Appendix 1 for recent publications and Appendix 2 for patents.)

1.8 SRI-CAT

The SRI-CAT has the principal mission of developing new and unique forefront instruments and techniques to advance the use of synchrotron radiation. The principal developers of the SRI-CAT are members of XFD (from the Insertion Device Group, Beamline Engineering Group, and X-ray Optics Group), and their primary responsibility is to perform R&D in support of user operations. Recently, new members have joined SRI-CAT from Purdue University, University of Houston, National Institute of Standards and Technology, Lawrence Berkeley National Laboratory, Stanford Synchrotron Radiation Laboratory, Cornell High Energy Synchrotron Source (CHESS), and many Australian institutions managed by the Australian Nuclear Science and Technology Organization.

Consistent with the main focus of SRI-CAT to support the needs of all the CATs, the following is a list of major accomplishments:

- Design, construction, and operation of standard and specialized insertion devices

- Diagnostics of radiation from the insertion devices

- Development of high heat load optics

- Design, construction, and testing of various "standard and modular" beamline components

- Evaluation of the performance of the EPICS-based beamline control and data acquisition hardware and software that will be used by many other CATs
- Initial evaluation and scrutiny of all beamline commissioning and operational procedures developed for the user beamlines by XFD Operations
- Evaluation of logic and technical performance of Personnel Safety Systems implemented on various experiment stations of SRI-CAT.
- Evaluation of the shielding performance of various XFD-designed experiment stations
- Testing of all safety procedures developed to support the APS user community

Towards the development of unique synchrotron techniques that are not generally available at other APS CAT beamlines, some members of SRI-CAT have defined objectives for a set of "strategic" instruments. These instruments are in an advanced stage of commissioning, and some are already being used by members of SRI-CAT to perform planned research. A short list of accomplishments to date is given below:

- Application of microbeam techniques
- Application of coherence-based techniques
- Development of 0.5 to 4 keV scientific capabilities
- Development of ultrahigh-resolution inelastic scattering techniques
- Application of nuclear coherent spectroscopy

The above accomplishments and future plans of SRI-CAT are discussed in more detail elsewhere in this document.

1.9 Collaborative Work with APS Users and Other Synchrotron Radiation Facilities

In 1991, XFD established a Collaborative Research Program (CRP) with potential users of the APS. In this program, a joint proposal is made by XFD staff members and interested APS users to perform R&D on a topic of general interest to APS users and to which both collaborating parties can bring their expertise and institutional resources. This program has led to many interesting results. During the past few years, owing to the heavy work load associated with beamline construction, the users have not responded to calls for CRP proposals. This program will begin to interest the users again as they finish commissioning of their beamlines. The APS users have also developed joint R&D proposals with XFD staff on problems of common interest to seek funds from new sources.

In recent years, the XFD staff has supported major activities related to construction at various other synchrotron facilities including NSLS, BESSY II, HASYLAB, and SPring-8, reflecting the regard of the world-wide synchrotron radiation community for the work performed by XFD staff.

1.10 Long-Term Strategic Plan for XFD

Strategic planning has been performed by XFD to develop new initiatives to meet future APS goals (described in Chapter 6). Considerable R&D is required in order to prepare the initiatives. Support for such R&D activities is currently not provided through the funding obtained from DOE. Hence support is derived mainly from the Laboratory Directed Research and Development (LDRD) funds distributed by the Argonne National Laboratory Director through a laboratory-wide competitive process. The XFD LDRD programs funded for the period 1996-1998 include:

1. CVD Diamond Imaging Detector (97-98)

2. Deep Etch Lithography (96-98)

3. Intensity Fluctuation Spectroscopy (96-98)

4. Heterodyne Correlation Spectroscopy (96-98)

5. Fabry-Perot Cavity for Sub-meV Resolution (97-99)

6. Anomalous Inelastic Scattering with meV Resolution (97-99)

7. Computational Analysis to Specify the Requirements of an Undulator to Demonstrate the SASE Concept and Prototype Testing (97-99)

XFD also constantly seeks other sources of funds to support R&D ideas that can either lead to new capabilities for the users or support possible new initiatives. Some of these are discussed in this *Progress Report.*